

REMARKS

In response to the Office Action mailed July 7, 2003, Applicant respectfully requests reconsideration. To further the prosecution of this application, claim amendments and arguments are submitted herewith.

Claims 1-18 and 27-34 were pending in this application. Claims 1 and 31-34 have been amended for the sole purpose of clarification. Thus, claims 1-18 and 27-34 are pending with claims 1, 12, 17, and 27 being independent claims.

I. Discussion of "Interference Filters"

Aspects of the present invention relate to interference filters, as may be used in image sensors. It should be appreciated that the label "interference filter" implies certain structural and functional features to those of skill in the art. Accordingly, labeling a filter as an "interference" filter can distinguish the filter from other types of filters, such as absorption filters. For purposes of the following discussion relating to the claim rejections, Applicant now provides a brief background of interference filters.

Functionally, an "interference filter" operates to filter incident radiation of some kind by means of interference effects, thus promoting or inhibiting the propagation through the filter of some or all of the incident radiation. Interference effects, such as constructive and destructive interference, are well known to those of skill in the art. It is known that interference effects can be exhibited within, for example, a thin film having an upper surface and a lower surface. As a specific example, interference effects can be found in thin films during photolithography processes (see, for example, the article by Bencher attached hereto as Exhibit I, page 1). Light may impinge upon the upper surface of the thin film, with a first portion of the light being reflected, and a second portion of the light propagating through the film. The second portion that propagates through the film may give rise to a reflected third portion that reflects from the lower surface of the film back into the film. The third portion may exhibit a phase shift relative to the first and/or second portions of light. Depending on the resulting phase, the third portion may interfere constructively or destructively with the first and/or second portions of light. Phase-shift cancellation occurs when the resulting phase of the third portion causes the cancellation of some or all of the second and/or third portions of light.

It is known that interference filters exhibit certain structural features which enable them to perform interferential filtering. Specifically, to understand and design a structure that exhibits phase-shift cancellation, it is known that one must consider various optical parameters, such as index of refraction n , extinction coefficient k , and thickness d of the materials being used to perform the phase-shift cancellation (Exhibit I, page 2). To ensure that a reflected wave will be equal in amplitude and opposite in phase to an incident wave, thus leading to destructive interference, proper choice of these three parameters is required (Exhibit I, page 2). In fact, attaining phase cancellation requires very tight control of process parameters, such as thickness (Exhibit I, page 2). The thickness of thin films may need to be controlled to within 15 Angstroms (Exhibit I, page 2).

Applicant has also provided Exhibits II and III as general background on interference effects.

II. Claim Rejections

Claims 1-6, 8, 12-15, 17, and 28-33 stand rejected under 35 U.S.C. § 103 as purportedly being unpatentable over U.S. Pat. No. 4,242,694 to Koike et al. (hereinafter Koike). Claims 1, 4, 6, 12, 13, 17, and 31-33 stand rejected under 35 U.S.C. § 102 as purportedly being unpatentable over U.S. Pat. No. 5,502,488 to Nagasaki et al. (hereinafter Nagasaki). Claims 27 and 34 stand rejected under 35 U.S.C. § 103 as purportedly being unpatentable over Koike considered together with U.S. Pat. No. 5,614,744 to Merrill. Claims 12, 17, 18, 27, and 32-34 stand rejected under 35 U.S.C. § 102 as purportedly being unpatentable over U.S. Pat. No. 4,996,578 to Motojima et al. (hereinafter Motojima). Claims 7, 9, 10, and 16 stand rejected under 35 U.S.C. § 103 as purportedly being unpatentable over Koike further considered with Motojima. Claim 7 stands rejected under 35 U.S.C. § 103 as purportedly being unpatentable over Nagasaki further considered with Motojima.

A. Brief Overview of References

In setting forth the above rejections, the Office Action asserts that the claimed "interference filter" reads on structures found in some of the references. Specifically, the Office action asserts that the claimed interference filter reads on layers 12R, 12G, 12B, and 13 of Koike. Also, the Office Action asserts that the claimed interference filter reads on layer 4 and layer 9 or

21 of Nagasaki. Additionally, the Office Action asserts that the claimed interference filter reads on layer 6₂ and layer 4 of Motojima.

Applicant has previously argued that such assertions are inappropriate. During the course of a telephone interview between Applicant's representatives and the Examiner, the Examiner expressed the opinion that the asserted structures inherently perform an interferential filtering function for some wavelength of light, even if not explicitly taught in the references. In light of the discussion of interference filters presented in Section I of this Amendment, as well as the following arguments, Applicant respectfully maintains the position that the asserted references do not teach the claimed interference filter, as would be known to one of skill in the art.

B. Discussion of Koike

In rejecting claims 1-6, 8, 12-15, 17, and 28-33 the Office Action asserts that layers 12R, 12G, 12B and layer 13, of Figure 2, correspond to the claimed interference filter. Figure 2 is described in column 7, lines 10-50. There is no portion of this discussion related to interference filtering. Rather, the purpose of the cited layers is to alter the storage capacitance of the structure (col. 7, lines 14-20). To this end, the thicknesses of layers 12R, 12G, and 12B are chosen based on equations (3), (4), and (5) (col. 7, lines 31-38), which also require use of equations (1) and (2). These equations pertain to controlling the capacitance of the structure, and not to controlling interference effects. There is no discussion of the index of refraction, extinction coefficient, or thickness relating to interference effects.

Moreover, the thicknesses of the layers 12R, 12G, and 12B are inappropriate for performing interferential filtering. Specifically, Koike shows that film 12B has a thickness of 5,000 Angstroms, 12G has a thickness of 1,600 Angstroms, and 12R has a thickness of 1,000 Angstroms (col. 7, lines 31-38). The thicknesses could alternatively be 10,000 Angstroms for 12B, 3,300 Angstroms for 12G, and 1,800 Angstroms for 12R (col. 7, lines 46-49). In either scenario, the layer for blue light is thickest, followed by the layer for green light, and then followed by the layer for red light. However, as taught in the present application, if the layers 12R, 12G, and 12B of Koike did correspond to the claimed interference filter, then the thickness of 12R would be the greatest, followed by 12G, and then followed by 12B, in exactly the opposite ordering from that shown by Koike to control capacitive effects (See page 2, lines 30-

page 3, line 2, and Figure 2 of present application). Thus, Koike actually teaches away from using layers 12R, 12G, and 12B and layer 13 as an interference filter.

Therefore, applicant respectfully submits that Koike does not teach or suggest an interference filter, and that one of skill in the art would not recognize Koike as teaching or suggesting an interference filter.

C. Claims 1-6, 8, 12-15, 17, and 28-33 Distinguish and Are Non-Obvious Over Koike

Claims 1-6, 8, 12-15, 17, and 28-33 stand rejected under 35 U.S.C. § 103 as purportedly being unpatentable over Koike. Applicant respectfully traverses this rejection.

Claim 1

Claim 1 is directed to an array of photodiodes made of regions of a second conductivity type formed in a semiconductive region of a first conductivity type, divided into three interleaved sub-arrays. Each sub-array corresponds to a respective color of light, and all photodiodes of a respective sub-array being coated with a same interference filter. The same interference filter includes at least one insulating layer of determined thickness coated with at least one conductive layer. A combined thickness of the at least one insulating layer and the at least one conductive layer being different for each sub-array, the determined thickness of said at least one insulating layer and said at least one conductive layer coating the respective sub-array determining the respective color of light that is interferentially filtered and provided to the respective sub-array. Said at least one conductive layer is electrically connected to the semiconductive region of the first conductivity type. The amendments to claim 1 have been made in response to the comments found on page 2 of the Office Action, and are made for the sole purpose of clarification. Support for the amendments may be found, for example, in Figure 2 and the corresponding description.

As discussed above in subsection II.B, Koike does not teach or suggest an interference filter. Applicant respectfully submits, as seen from the discussion in Section I of this Amendment, that the term “interference filter” has a certain meaning to one of skill in the art, and must be accorded the appropriate significance. Accordingly, Applicant respectfully requests that the rejection of claim 1 under 35 U.S.C. § 103 be withdrawn.

Claims 2-11 and 28-31 depend from claim 1 and are allowable for at least the same reasons.

Claim 12

Claim 12 is directed to a photodiode comprising a semiconductor substrate of a first conductivity type, a semiconductive region of a second conductivity type formed in said semiconductor substrate, and a multilayer interference filter disposed over said semiconductive region. The multilayer interference filter includes at least one insulating layer having a predetermined thickness, and a conductive layer disposed over said at least one insulating layer, wherein said conductive layer includes a conductive portion that electrically connects said conductive layer to said semiconductor substrate of the first conductivity type. The predetermined thickness of said at least one insulating layer, in combination with said conductive layer, is adapted to interferentially filter a particular wavelength of light.

As discussed in connection with claim 1, Koike does not teach or suggest a multilayer interference filter, as claimed. Thus, Applicant respectfully requests that the rejection of claim 12 under 35 U.S.C. § 103 be withdrawn.

Claims 13-16 and 32 depend from claim 12 and are allowable for at least the same reasons.

Claim 17

Claim 17 recites, *inter alia*, a photodiode comprising a semiconductor substrate of a first conductivity type, a semiconductive region of a second conductivity type formed in said semiconductor substrate, and a multilayer interference filter disposed over said semiconductive region. As with claims 1 and 12, the claimed interference filter is not taught or suggested by Koike, contrary to the assertion in the Office Action. Therefore, Applicant respectfully requests that the rejection of claim 12 under 35 U.S.C. § 103 be withdrawn.

Claims 18 and 33 depend from claim 17 and are allowable for at least the same reasons.

D. Discussion of Nagasaki

In rejecting claims 1, 4, 6, 12, 13, 17, and 31-33 the Office Action asserts that the claimed interference filter reads on layer 4 and layer 9 or 21, shown in Figures 1 and 3 of Nagasaki, respectively. With reference to Figure 1, Nagasaki shows a pixel comprising a MOS

transistor 5, photodiode 8, and capacitor 10 (col. 6, lines 12-17). The capacitor 10 comprises capacitor electrode 9, capacitor insulating film 4, and source region 2 (col. 6, lines 35-38). There is no discussion of the index of refraction, extinction coefficient, or thickness of layer 4 or layer 9. The dielectric constant of layer 4 is described in relation to capacitive effects only (col. 7, lines 13-19). There is no discussion relating to interference effects. Figure 3 shows a modification of the structure of figure 1, and includes transparent electrode 21 (col. 8, lines 45-52). Again, there is no discussion relating to interference effects or the associated optical parameters. Indeed, nowhere does Nagasaki even discuss color filtering.

E. Claims 1, 4, 6, 12, 13, 17, and 31-33 Distinguish and Are Non-Obvious Over Nagasaki

Claims 1, 4, 6, 12, 13, 17, and 31-33 stand rejected under 35 U.S.C. § 102 as purportedly being unpatentable over Nagasaki. As discussed above, each of claims 1, 12, and 17 recites an interference filter. Nagasaki fails to teach or suggest an interference filter, as claimed. Therefore, Nagasaki lacks at least this limitation of claims 1, 12, and 17. Accordingly, Applicant respectfully requests that the rejection of claims 1, 12, and 17 under 35 U.S.C. § 102 be withdrawn.

Claims 2-11 and 28-31 depend from claim 1 and are allowable for at least the same reasons.

Claims 13-16 and 32 depend from claim 12 and are allowable for at least the same reasons.

Claims 18 and 33 depend from claim 17 and are allowable for at least the same reasons.

E. Discussion of Merrill

Merrill is directed to a CMOS-Based active pixel array. The CMOS active pixel image sensor design aids in reduction of photosensor leakage (col. 1, lines 8-13). Figure 7 illustrates a cross-sectional view of a low leakage cell (col. 3, lines 23-24), and is discussed in column 4, lines 51-61. There is no discussion within this portion of Merrill relating to interference filters.

F. Claims 27 and 34 Distinguish and Are Non-Obvious Over the Combination of Koike and Merrill

Claims 27 and 34 stand rejected under 35 U.S.C. § 103 as purportedly being unpatentable over Koike considered together with Merrill. Applicant respectfully traverses this rejection

Claim 27 recites a photodiode comprising, *inter alia*, a semiconductor substrate of a first conductivity type, a semiconductive region of a second conductivity type formed in said semiconductor substrate, and a multilayer interference filter disposed over said semiconductive region.

In asserting the combination of Koike and Merrill, the Office Action relies on the above-stated argument that the layers 12R, 12G, 12B and layer 13, of Figure 2 of Koike, correspond to the claimed interference filter. As discussed in subsection II.B of this Amendment, Koike does not teach or suggest an interference filter, so that assertion in the Office Action is inappropriate. As discussed in subsection II.E, Merrill does not teach or suggest an interference filter, and therefore does not cure the deficiencies of Koike. No combination of Koike and Merrill teaches or suggests all of the limitations of claim 27. Accordingly, Applicant respectfully requests that the rejection of claim 27 under 35 U.S.C. § 103 be withdrawn.

Claim 34 depends from claim 27 and is allowable for at least the same reasons.

G. Discussion of Motojima

Motojima is directed to a photodetector for converting an optical signal into an electric signal, as well as a semiconductor element comprising an optically transmissible conductive film formed through an insulating film (Abstract). Figure 5 illustrates a sectional view of Motojima's semiconductor device.

Referring to Figure 5, optically transmissible conductive film 4 is formed above layer 6₂. Contrary to the assertion on page 4 of the Office Action, these layers do not constitute an interference filter. There is no discussion of the index of refraction of the layers, or the thicknesses of the layers. Thus, the appropriate optical characteristics are not taught, and one of skill in the art would not be taught by Motojima that the cited layers constitute an interference filter.

H. Claims 12, 17, 18, 27, and 32-34 Distinguish Over Motojima

Claims 12, 17, 18, 27, and 32-34 stand rejected under 35 U.S.C. § 102 as purportedly being unpatentable over Motojima. Applicants respectfully traverse these rejections.

Each of independent claims 12, 17, and 27 recites a limitation of an interference filter. As discussed in subsection II.G of this Amendment, Motojima does not teach or suggest an interference filter, as would be recognized by one of skill in the art.

Accordingly, Applicant respectfully requests that the rejection of claims 12, 17, and 27 under 35 U.S.C. § 102 be withdrawn.

Claims 13-16 and 32 depend from claim 12 and are allowable for at least the same reasons.

Claims 18 and 33 depend from claim 17 and are allowable for at least the same reasons.

Claim 34 depends from claim 27 and is allowable for at least the same reasons.

III. Claim Amendments

Claim 1 has been amended as described in subsection II.C of this Amendment.

Claims 31-34 have been amended in response to the comments on page 2 of the Office Action. Specifically, Applicant has clarified that the effective capacitance of the photodiode is increased. Support for these amendments can be found, for example, on page 3, lines 15-18 of the written description.

Claim 31 has also been amended in response to the comments pertaining to the conductive layer, as found on page 2 of the Office Action.

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- 15 -

Art Unit: 2811

CONCLUSION

In view of the foregoing amendments and remarks, this application should now be in condition for allowance. A notice to this effect is respectfully requested. If the Examiner believes, after this amendment, that the application is not in condition for allowance, the Examiner is requested to call the Applicant's attorney at the telephone number listed below.

If this response is not considered timely filed and if a request for an extension of time is otherwise absent, Applicant hereby requests any necessary extension of time. If there is a fee occasioned by this response, including an extension fee, that is not covered by an enclosed check, please charge any deficiency to Deposit Account No. 23/2825.

Respectfully submitted,
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